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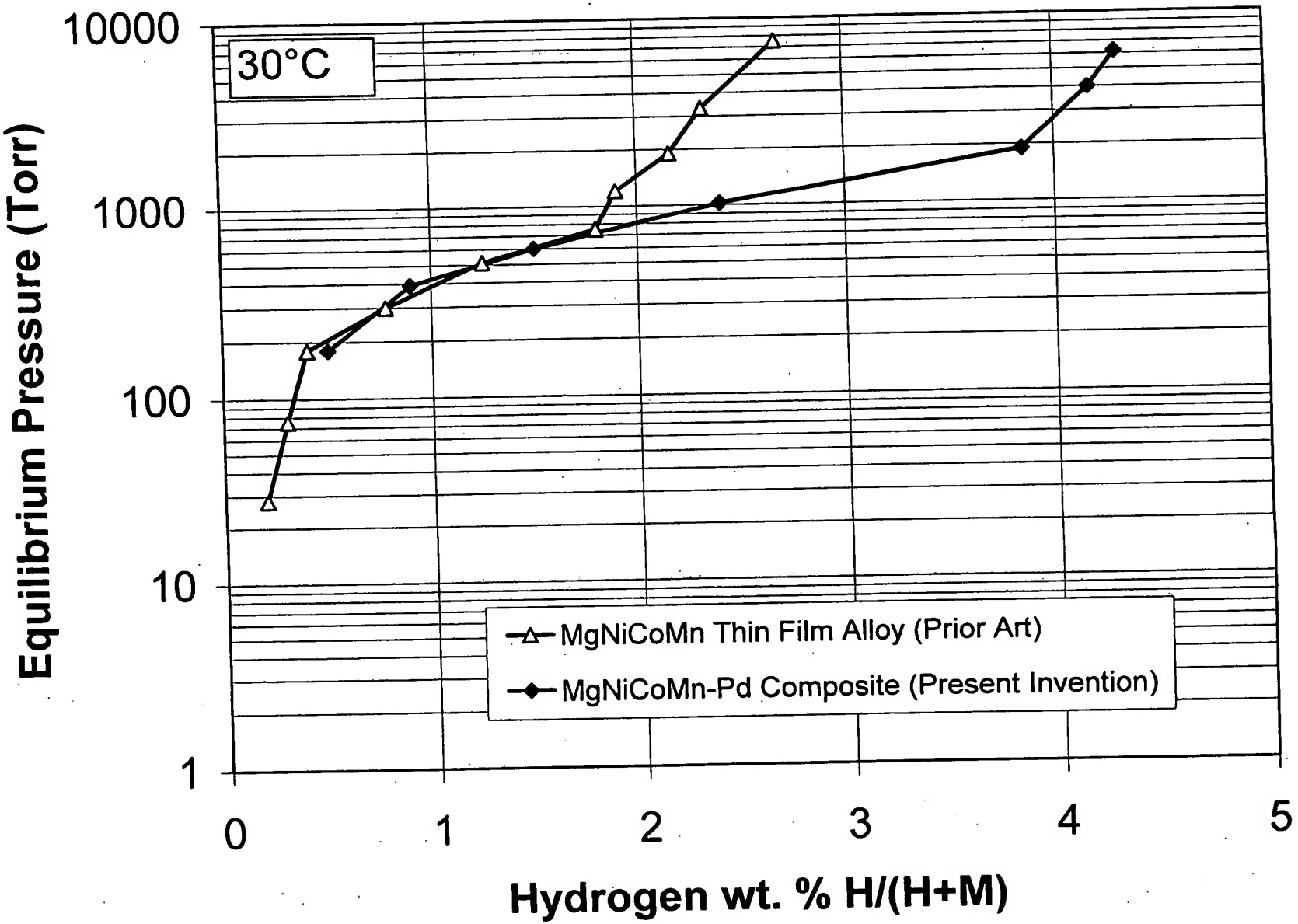

30°C
10000
1000
100
10
1
Equilibrium Pressure (Torr)
0
1
2
3
4
5
Hydrogen wt. % H/(H+M)
MgNiCoMn Thin Film Alloy (Prior Art)
MgNiCoMn-Pd Composite (Present Invention)

Figure 1

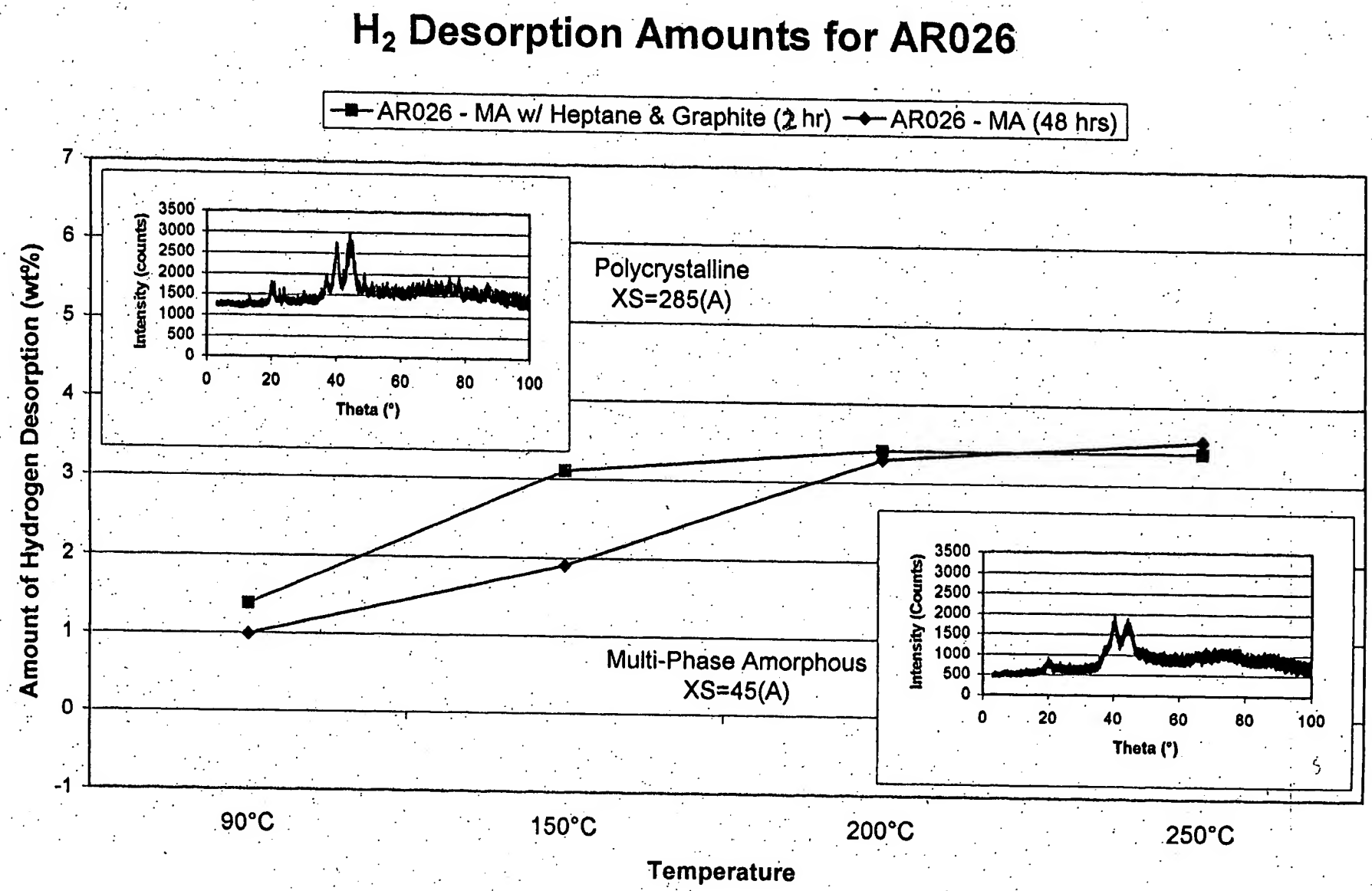

H2 Desorption Amounts for AR026
AR026 - MA w/ Heptane & Graphite (2 hr)
AR026 - MA (48 hrs)
Amount of Hydrogen Desorption (wt%)
7
6
5
4
3
2
1
0
-1
Intensity (counts)
3500
3000
2500
2000
1500
1000
500
0
0
20
40
60
80
100
Theta (°)
Polycrystalline
XS=285(A)
Multi-Phase Amorphous
XS=45(A)
Intensity (Counts)
Theta (°)
90°C
150°C
200°C
250°C
Temperature

Figure 2

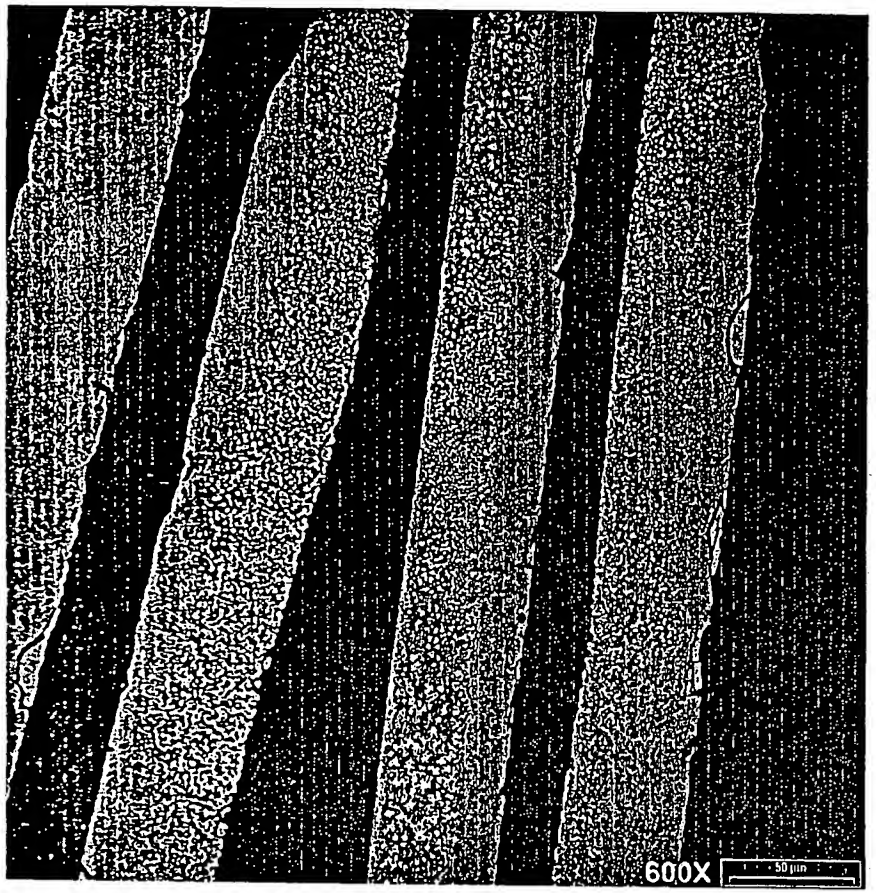


Figure 3A

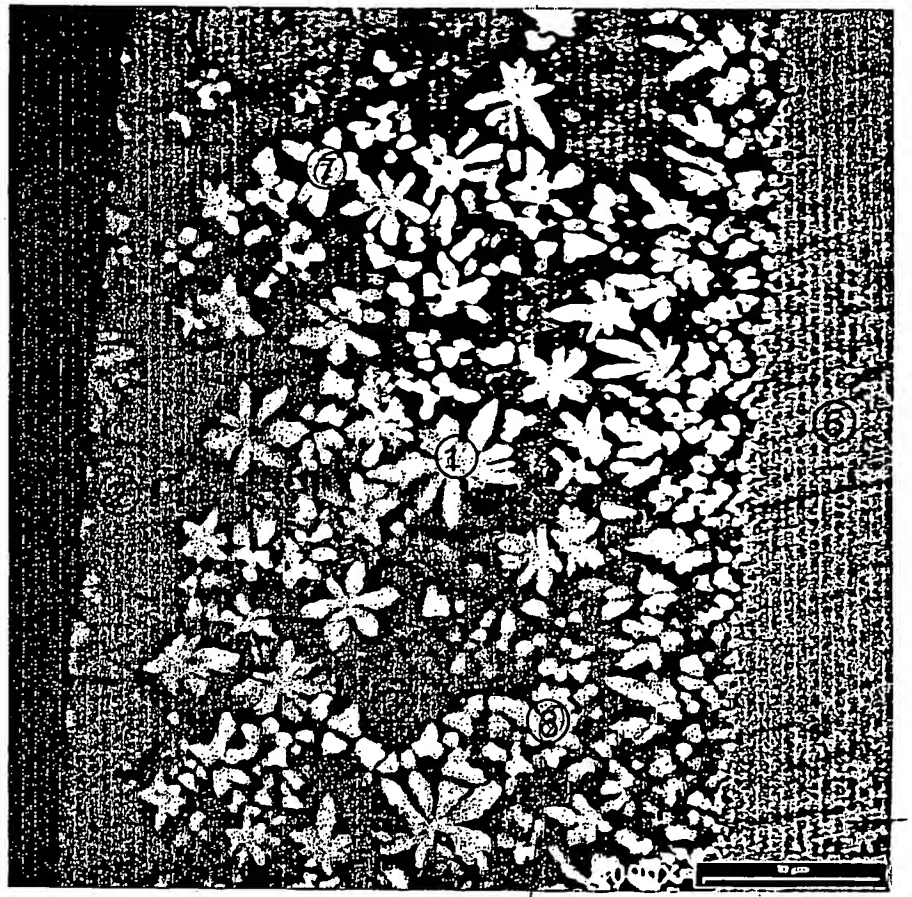


Figure 3B

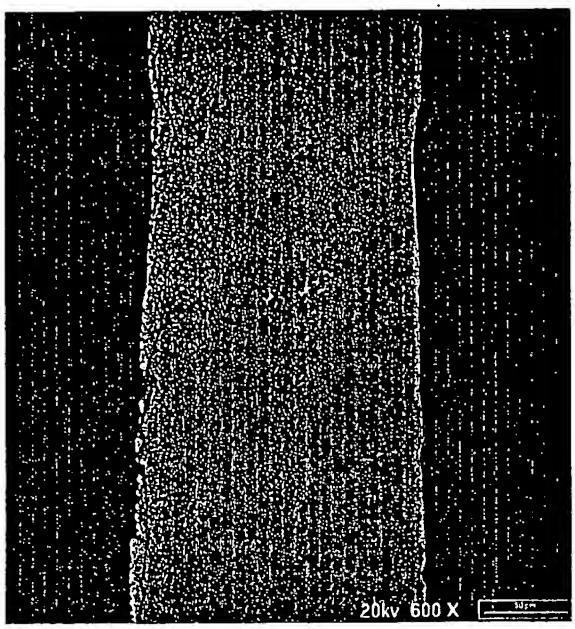


Figure 4

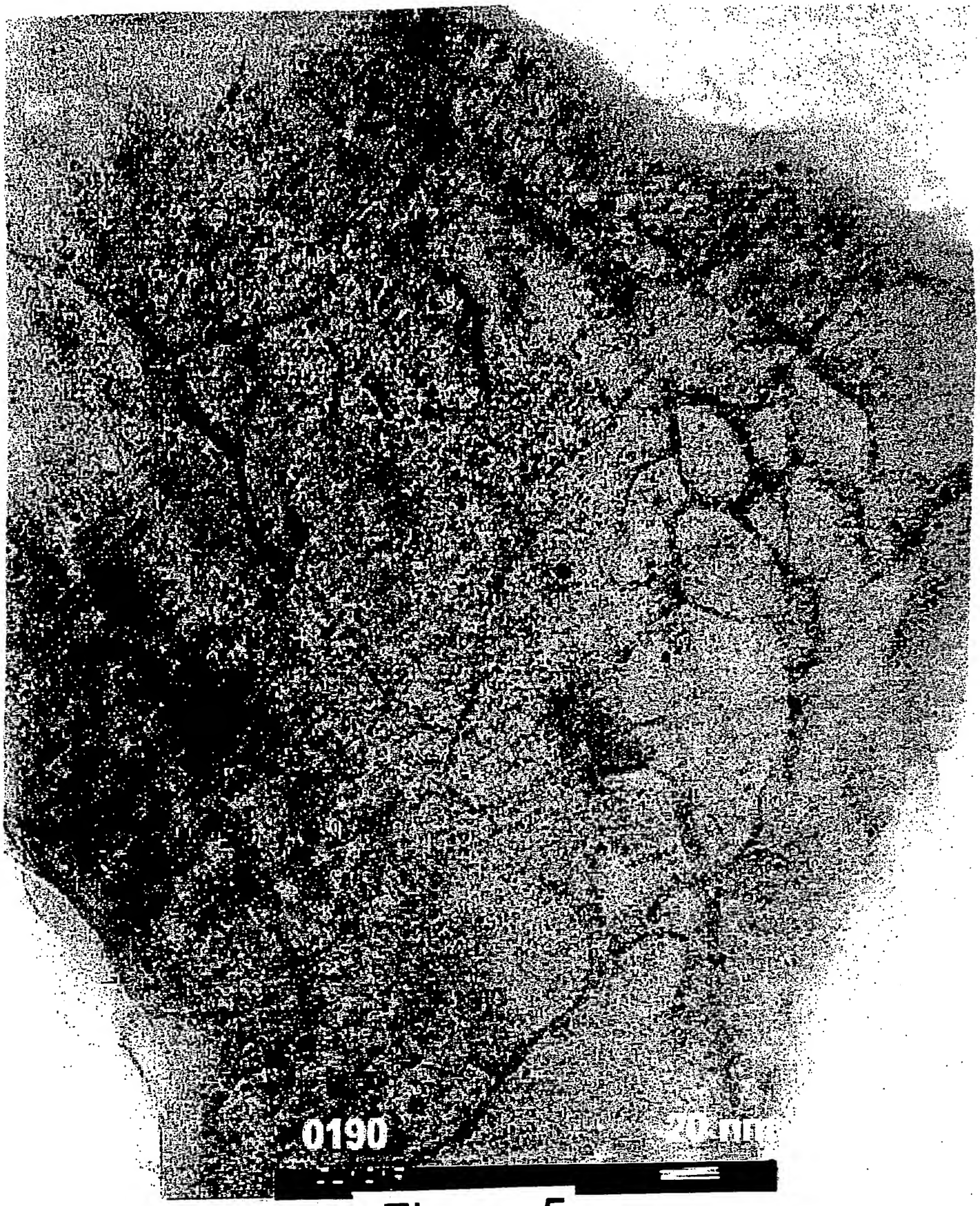


Figure 5

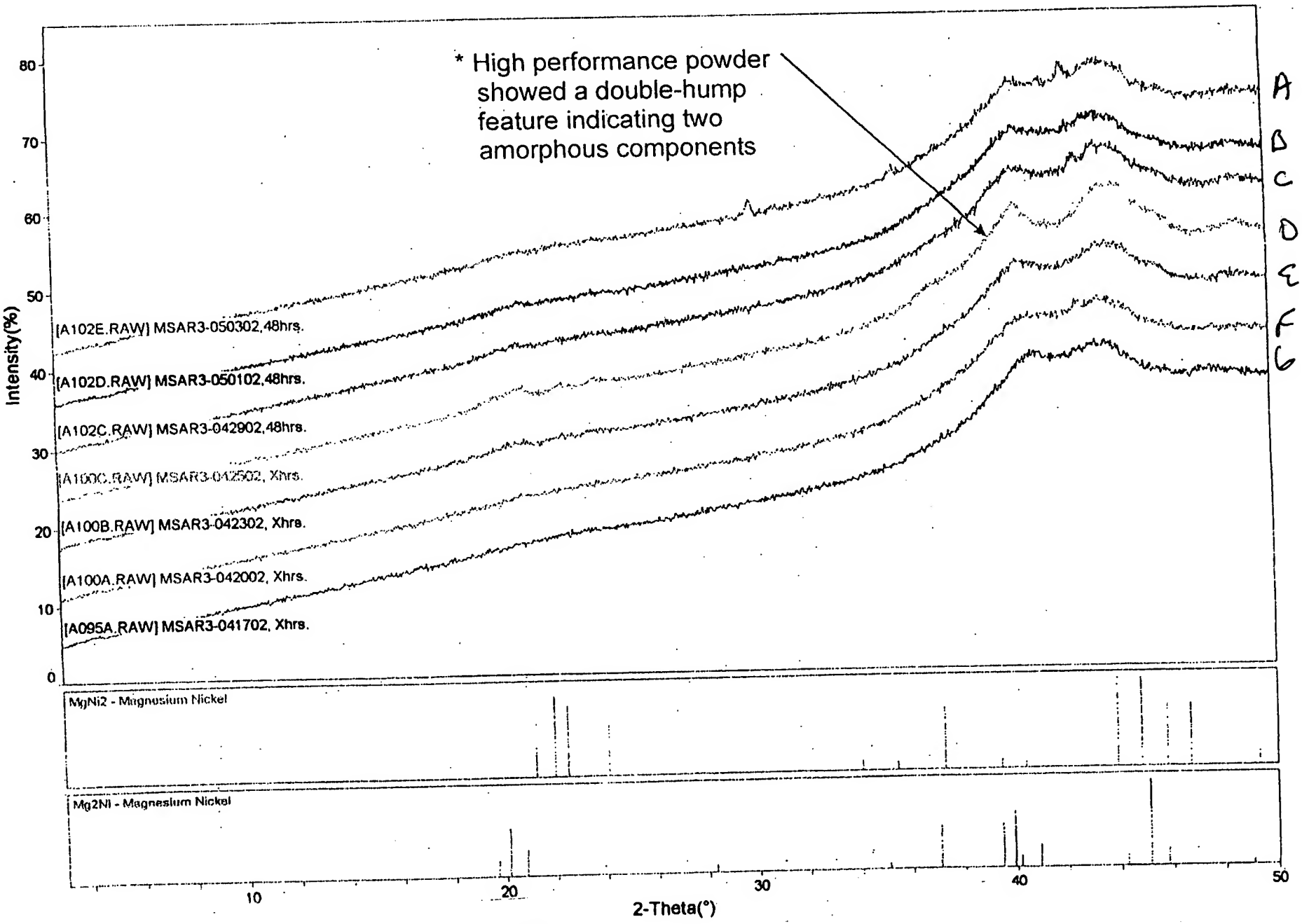

* High performance powder showed a double-hump feature indicating two amorphous components
A
B
C
D
E
F
G
[A102E.RAW] MSAR3-050302,48hrs.
[A102D.RAW] MSAR3-050102,48hrs.
[A102C.RAW] MSAR3-042902,48hrs.
[A100C.RAW] MSAR3-042502, Xhrs.
[A100B.RAW] MSAR3-042302, Xhrs.
[A100A.RAW] MSAR3-042002, Xhrs.
[A095A.RAW] MSAR3-041702, Xhrs.
Intensity(%)
0
10
20
30
40
50
60
70
80
MgNi2 - Magnesium Nickel
Mg2Ni - Magnesium Nickel
10
20
30
40
50
2-Theta(°)

Figure 6

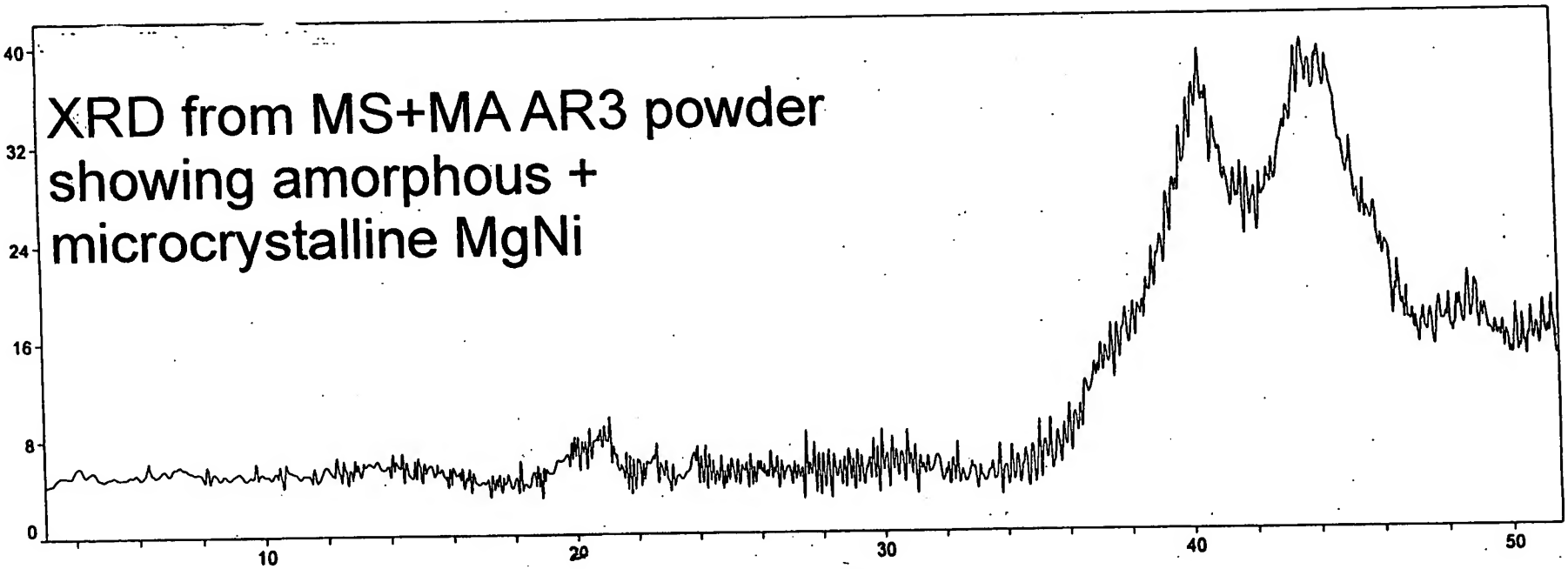


Figure 7B

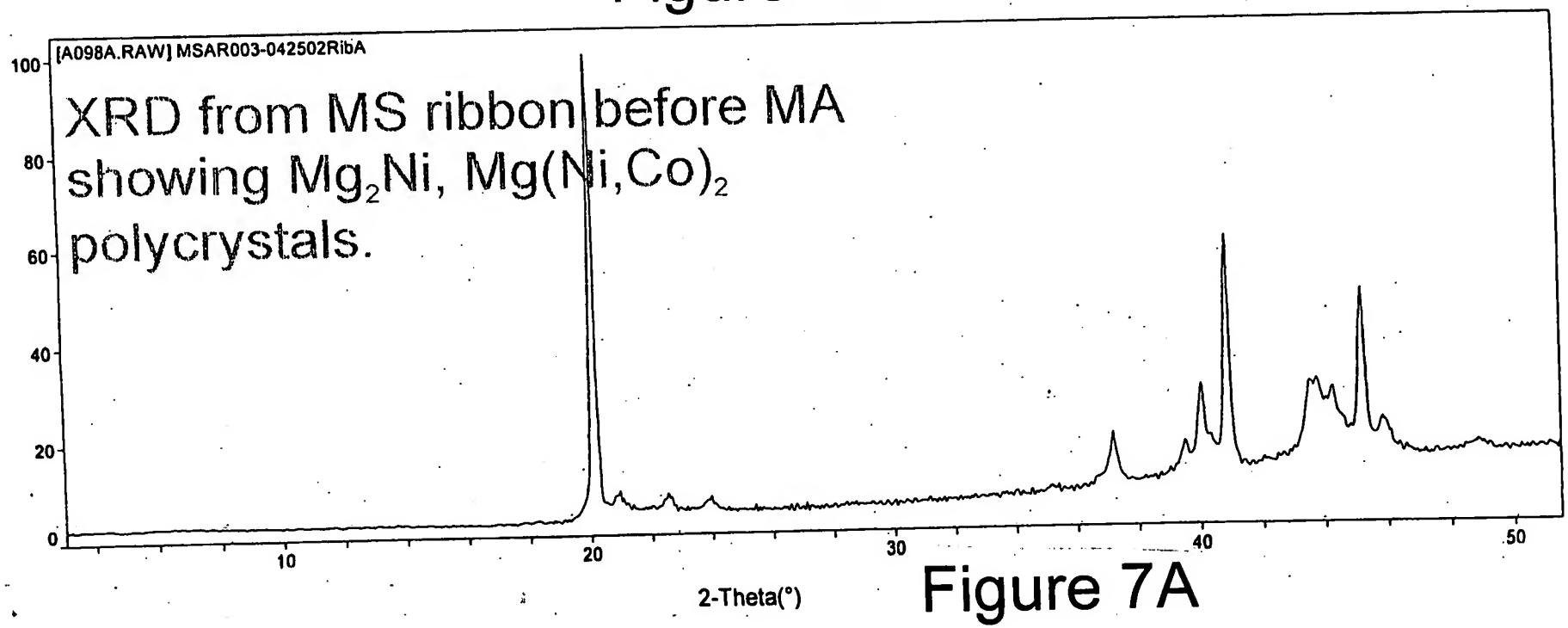


Figure 7A

H_2 Desorption Amounts for AR031 Material

(4 hour Desorption Time)

A-AR031- 2 hr Grind w/ Heptane and Graphite in Glove Box, Pressed in Ar - Coated w/ Pd (Cycle 2)
B-AR031- 2 hr Grind w/ Heptane and Graphite in Glove Box, Pressed in Ar - Coated w/ Fe (Cycle 2)
C-AR031- 2 hr Grind w/ Heptane and Graphite in Glove Box, Pressed in Ar - Coated w/ 10Å Pd & 10Å Fe
D-AR031- 2 hr Grind w/ Heptane and Graphite in Glove Box, Pressed in Ar - Coated w/ 100Å Pd & 100Å Fe (Cycle 2)

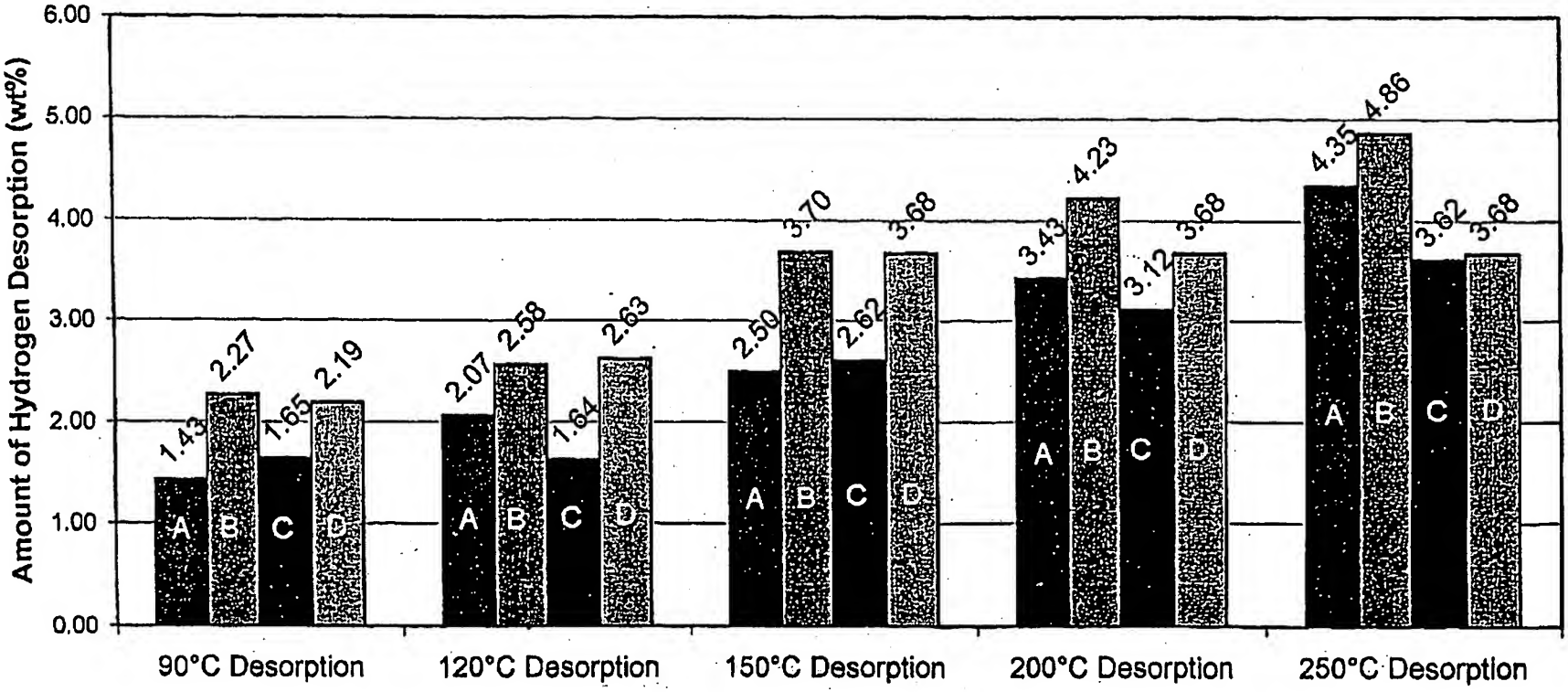


Figure 8A

H_2 Desorption Amounts for AR026 and AR031

2 hr Grind w/ Heptane and Graphite in Glove Box, Press in Ar

(4 hour Desorption Time)

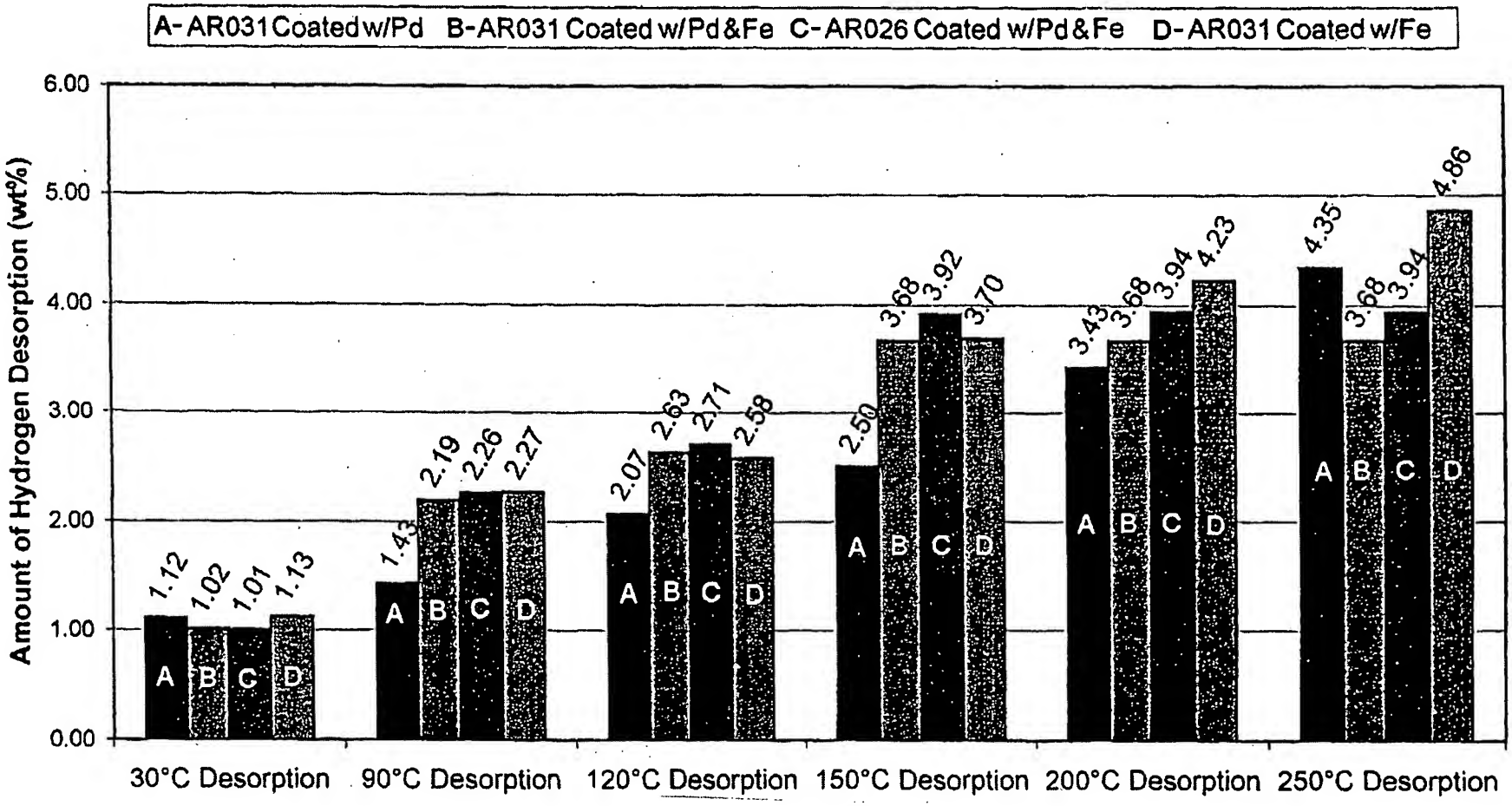
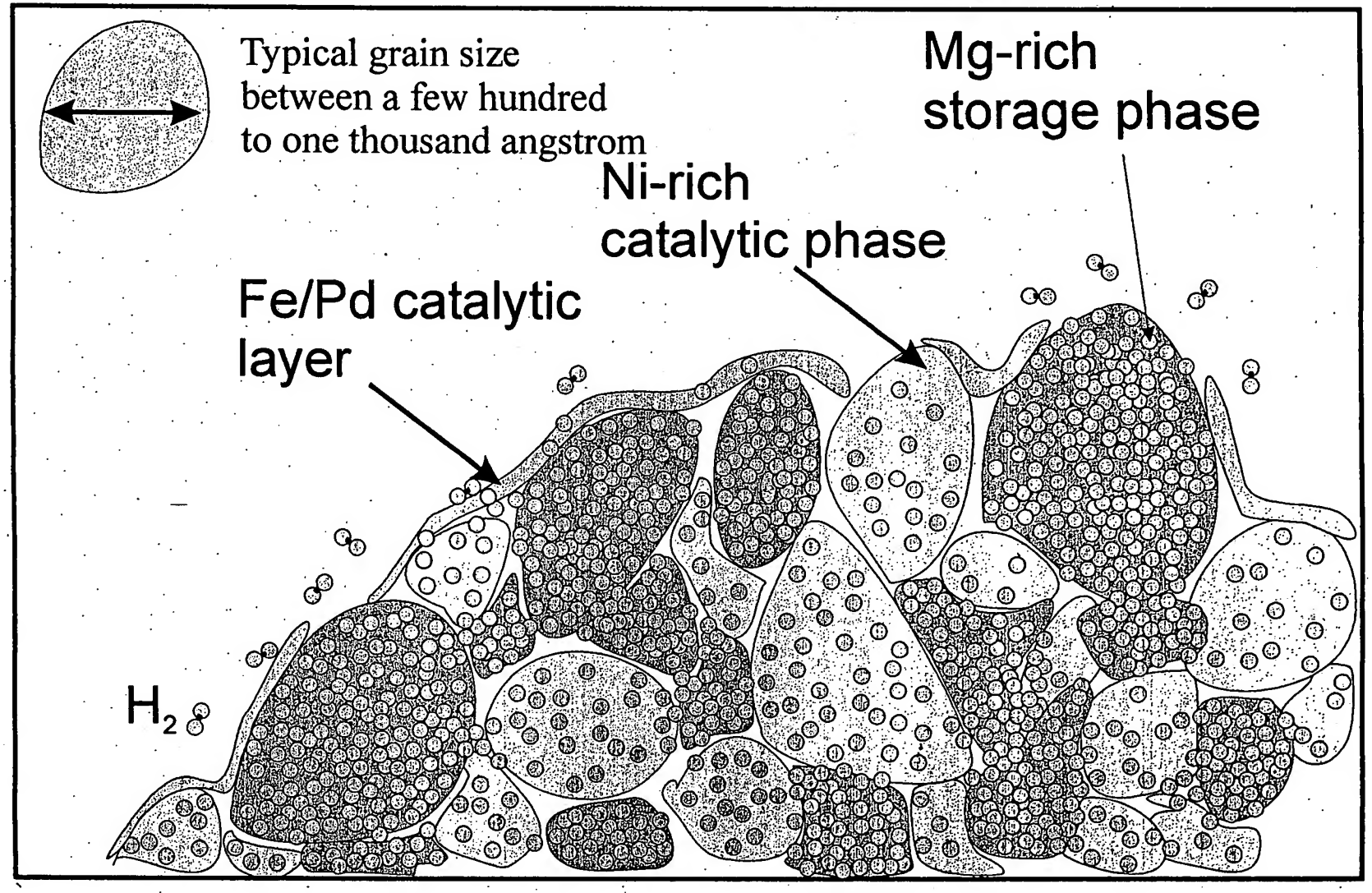


Figure 8B

Hydrogen Desorption in Mg-based AR Material



* Pd-layer only makes limited contribution to H-desorption due to low H-content
* The surface of Mg-rich storage phase may be the main area to recombine the H-atoms.

Figure 9

Ovonic Battery Company

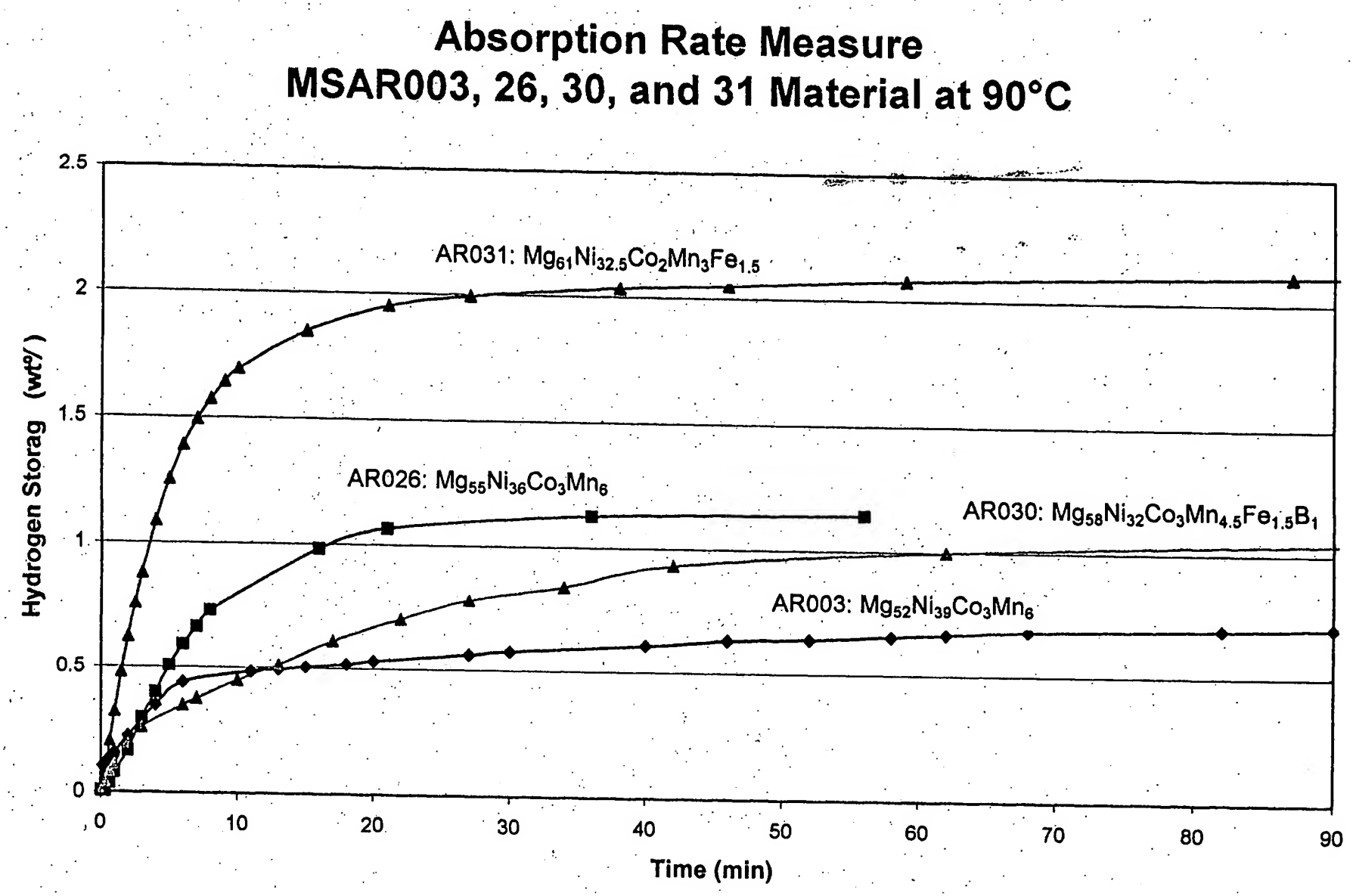

Absorption Rate Measure
MSAR003, 26, 30, and 31 Material at 90°C
Hydrogen Storag (wt%)
Time (min)
AR031: Mg61Ni32.5Co2Mn3Fe1.5
AR026: Mg55Ni36Co3Mn6
AR030: Mg58Ni32Co3Mn4.5Fe1.5B1
AR003: Mg52Ni39Co3Mn6
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90

Figure 10

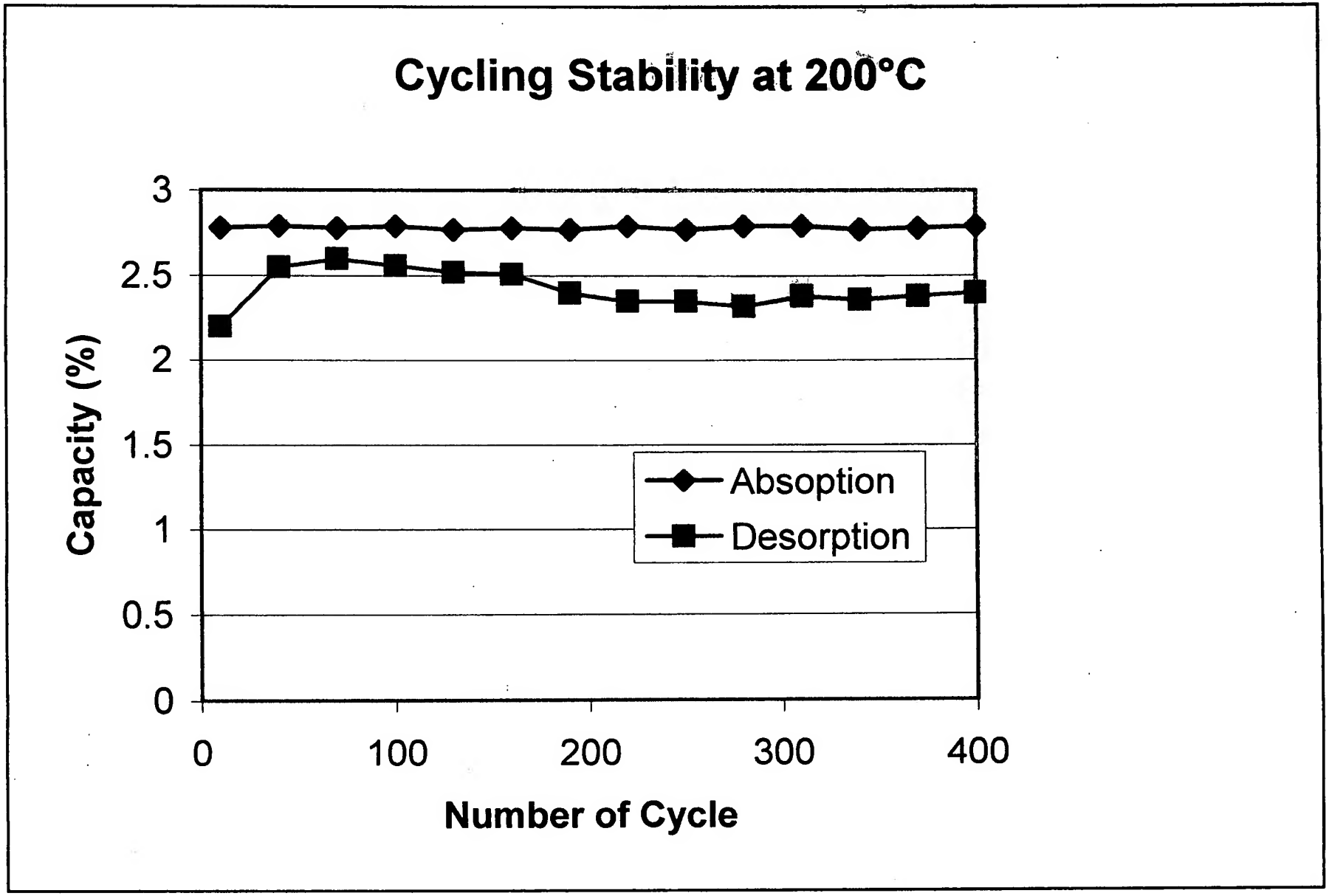

Cycling Stability at 200°C
Capacity (%)
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
Number of Cycle
Absoption
Desorption

Figure 11

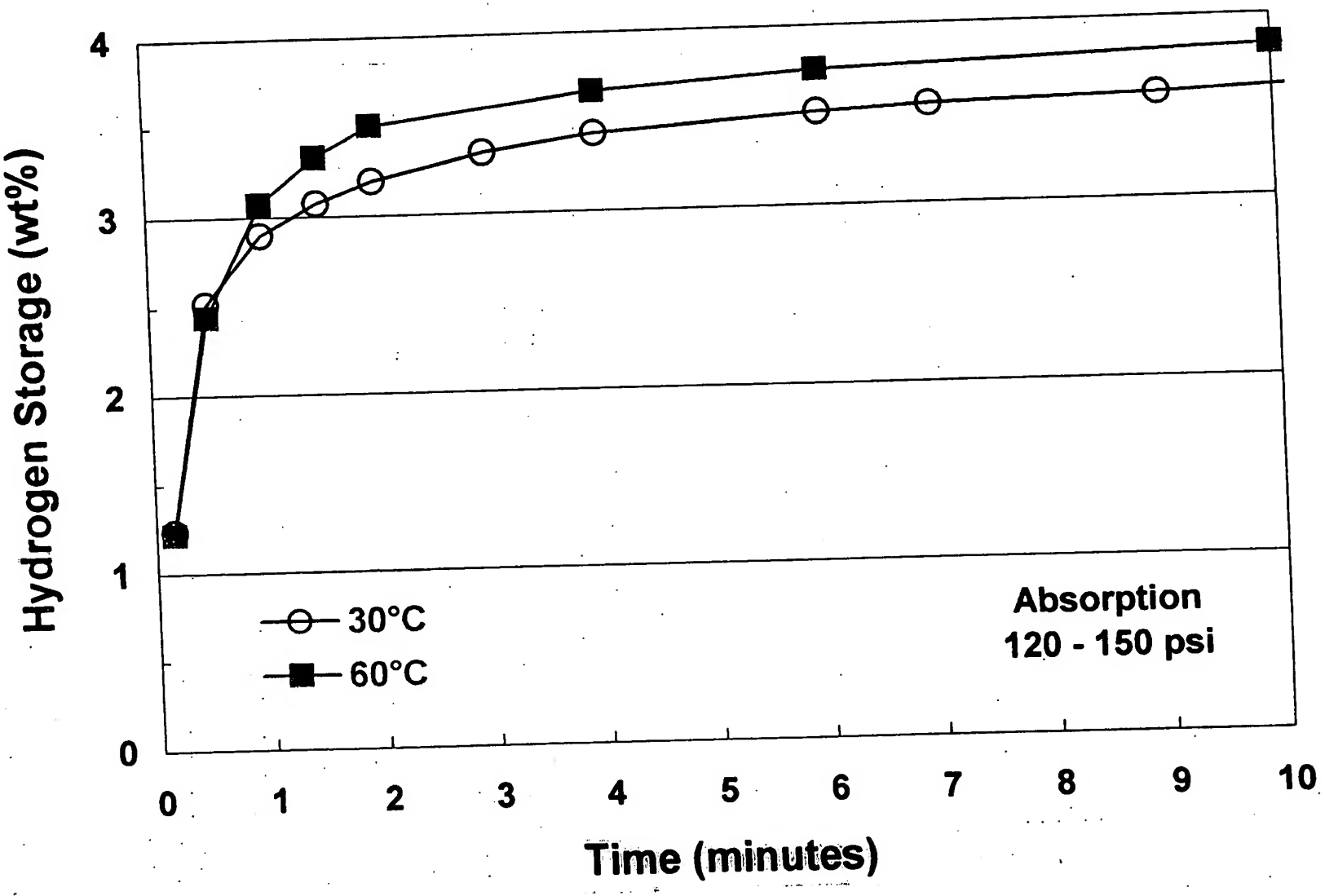

Hydrogen Storage (wt%)
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
Time (minutes)
30°C
60°C
Absorption
120 - 150 psi

Figure 12

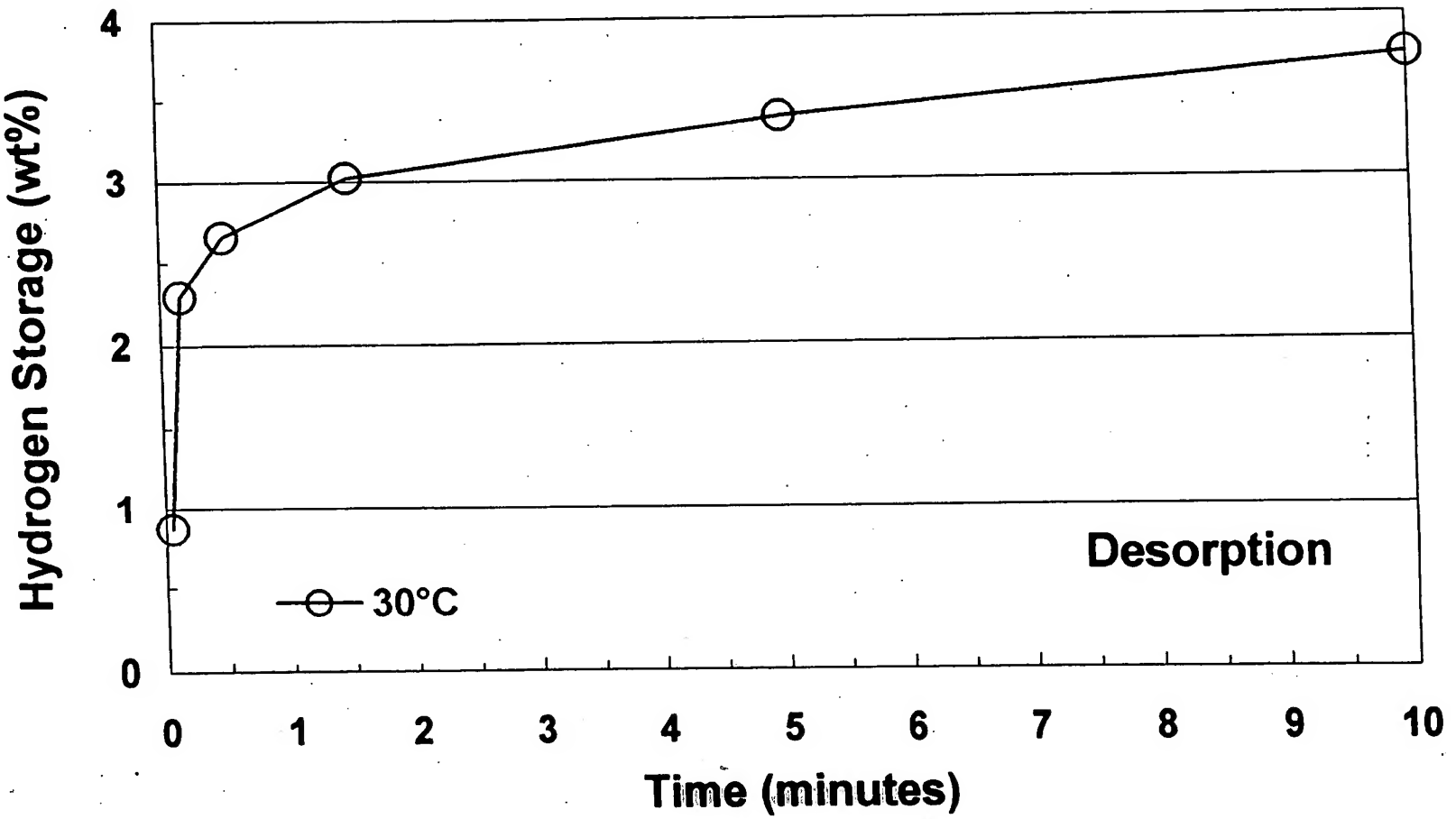

Hydrogen Storage (wt%)
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
Time (minutes)
30°C
Desorption

Figure 13

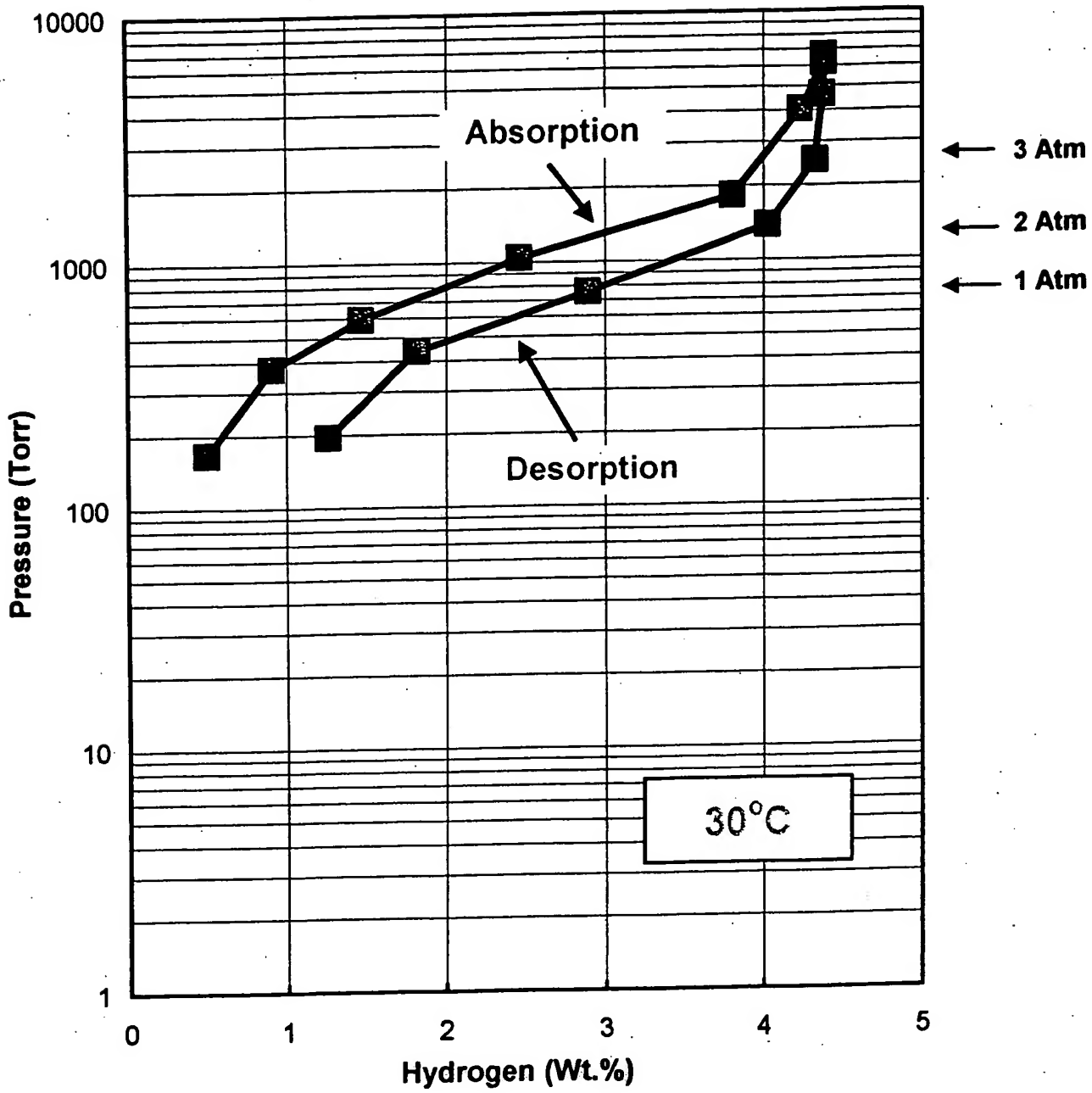

10000
1000
100
10
1
Pressure (Torr)
0
1
2
3
4
5
Hydrogen (Wt.%)
Absorption
Desorption
3 Atm
2 Atm
1 Atm
30°C

Figure 14

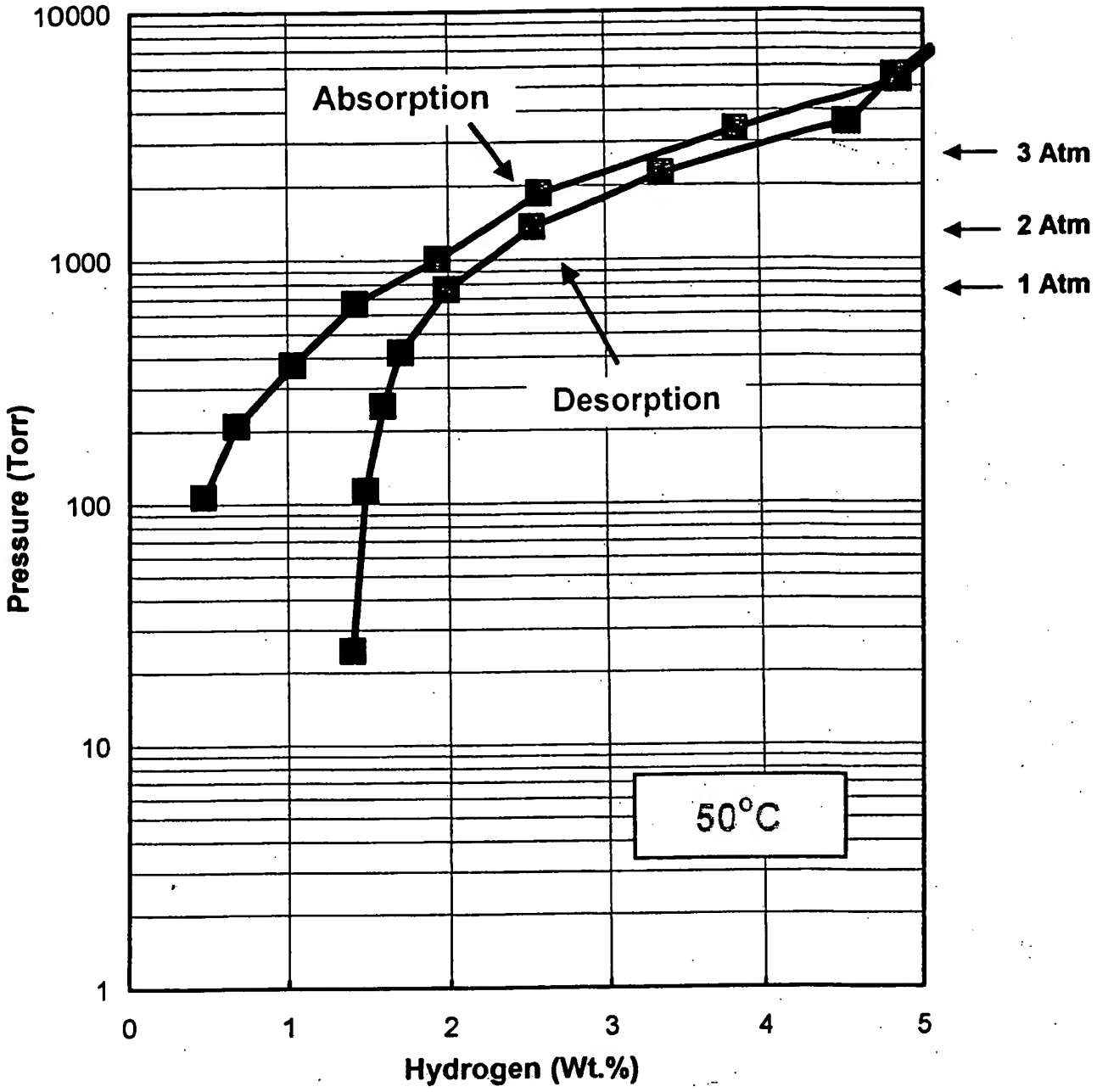

10000
1000
100
10
1
Pressure (Torr)
0
1
2
3
4
5
Hydrogen (Wt.%)
Absorption
Desorption
3 Atm
2 Atm
1 Atm
50°C

Figure 15

200°C PCT Measurement Result

AR026: $Mg_{55}Ni_{36}Co_3Mn_6$
AR003: $Mg_{52}Ni_{39}Co_3Mn_6$
AR037: $Mg_{47}Ni_{44}Co_3Mn_6$
AR038: $Mg_{42}Ni_{49}Co_3Mn_6$

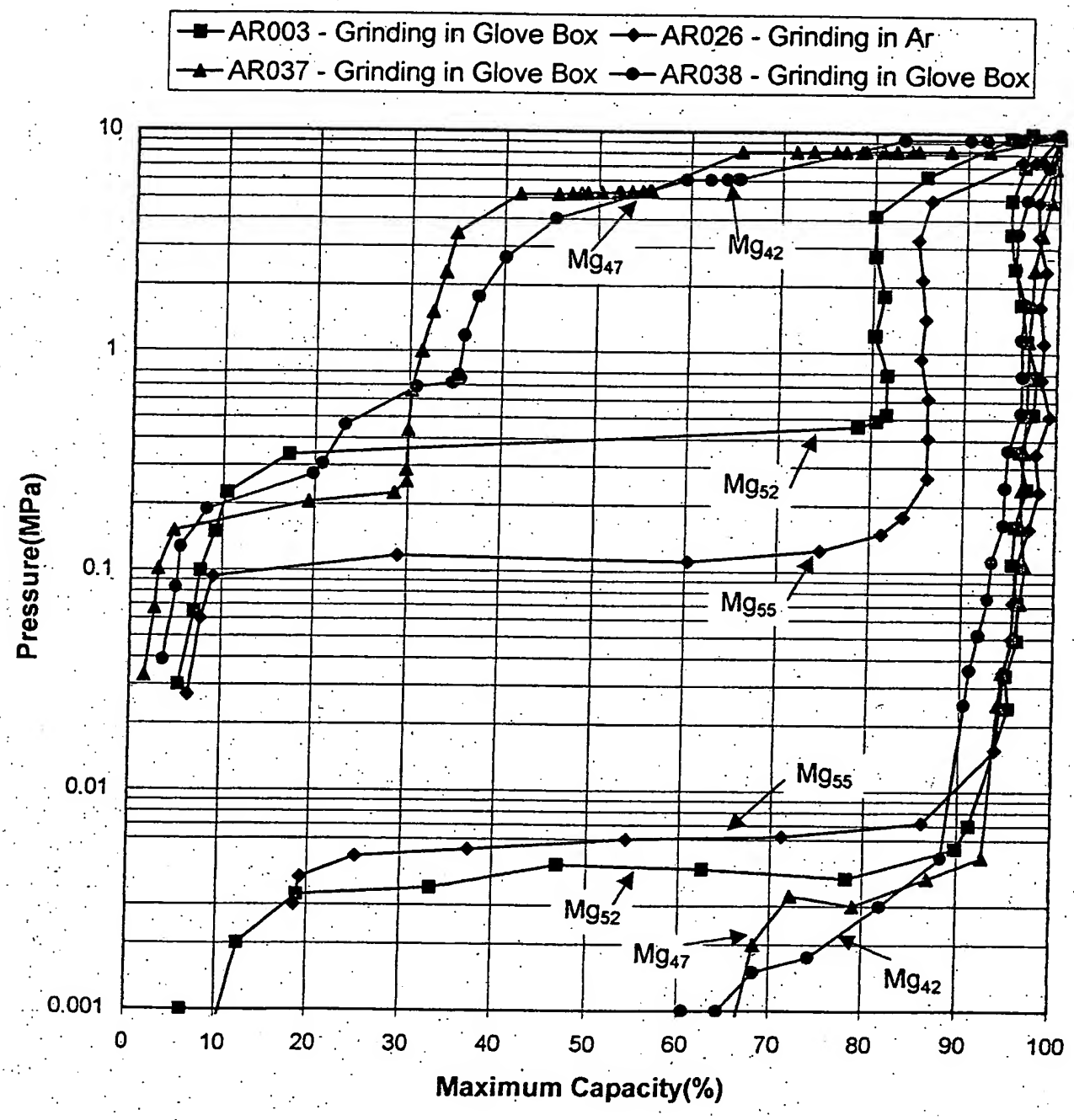


Figure 16

Plateau Pressure Comparison at 200°C
Based on Magnesium Content

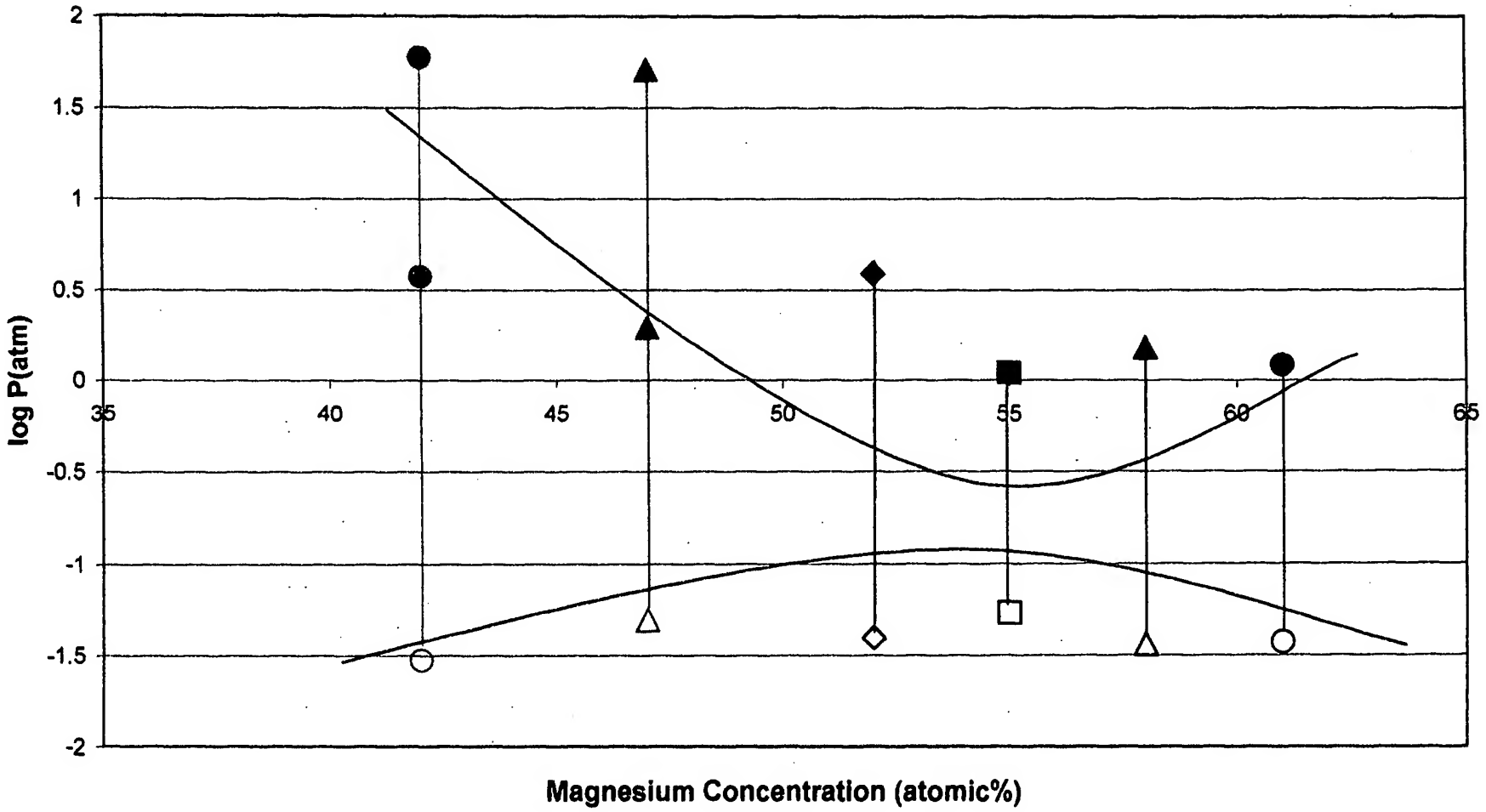


Figure 17

8/20/2003

Improvement of Low-Temperature MgNiCoMn Alloy Processing

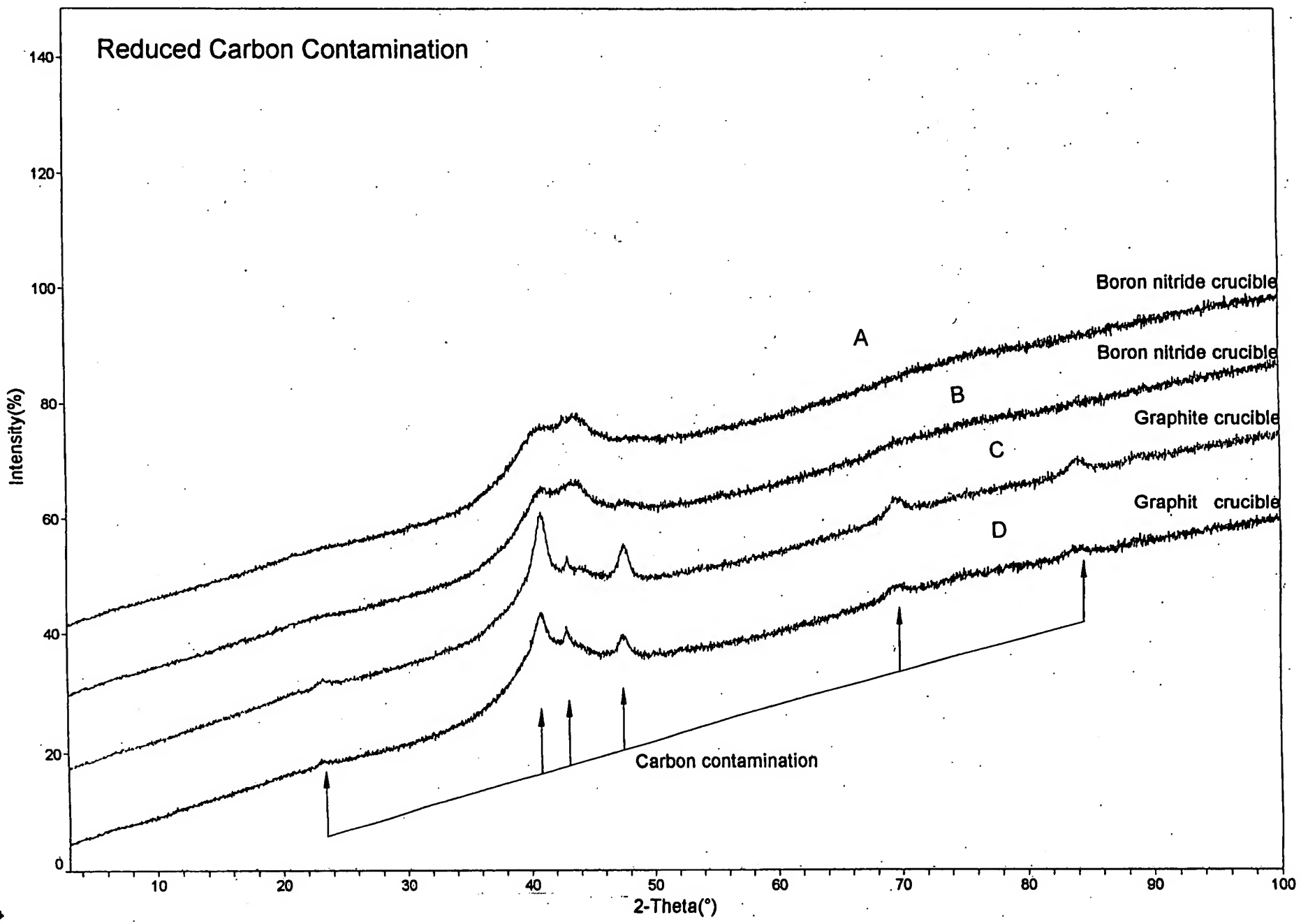


Figure 18

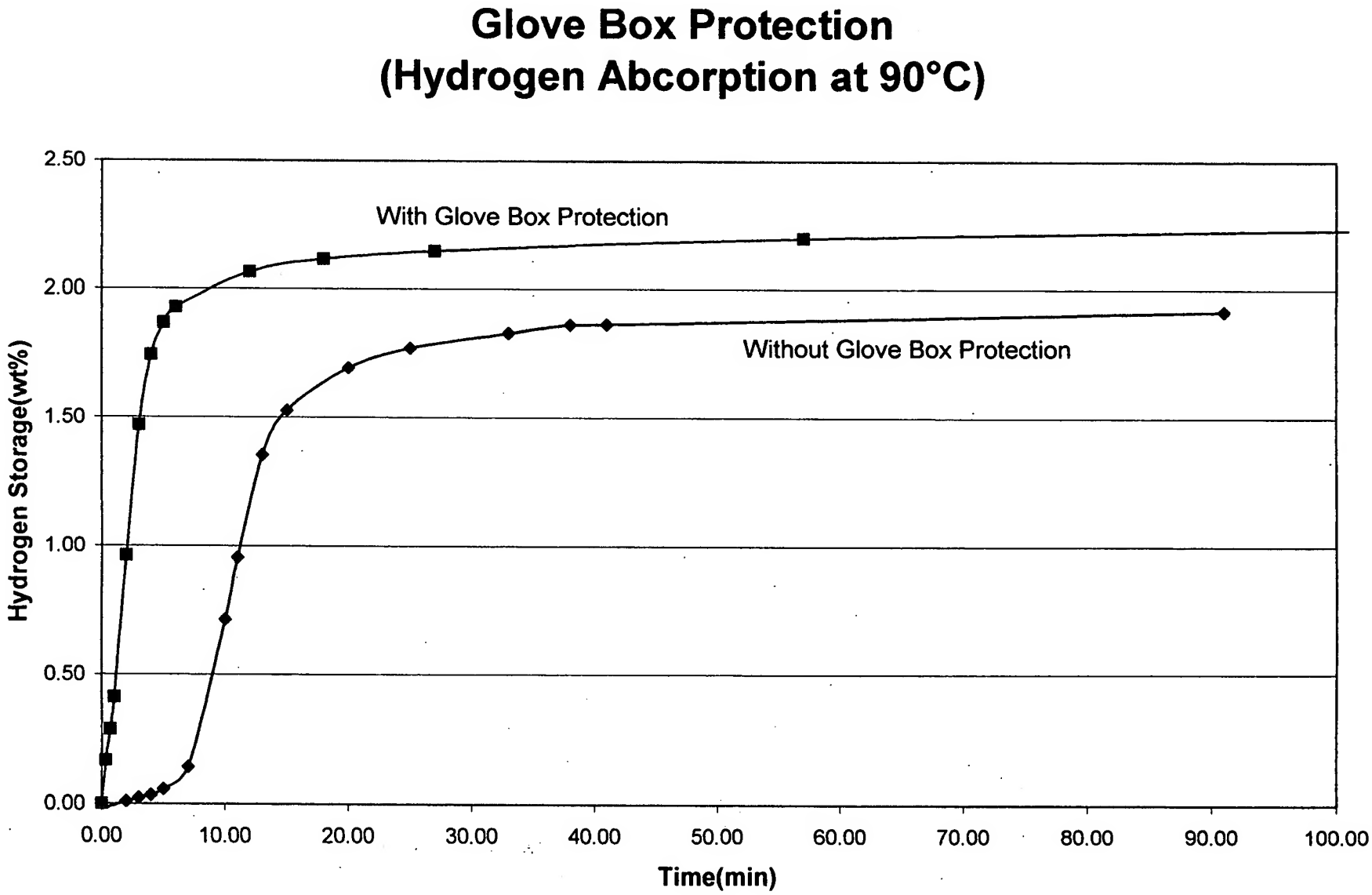

Glove Box Protection
(Hydrogen Abcorption at 90°C)
With Glove Box Protection
Without Glove Box Protection
Hydrogen Storage(wt%)
Time(min)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00

Figure 19

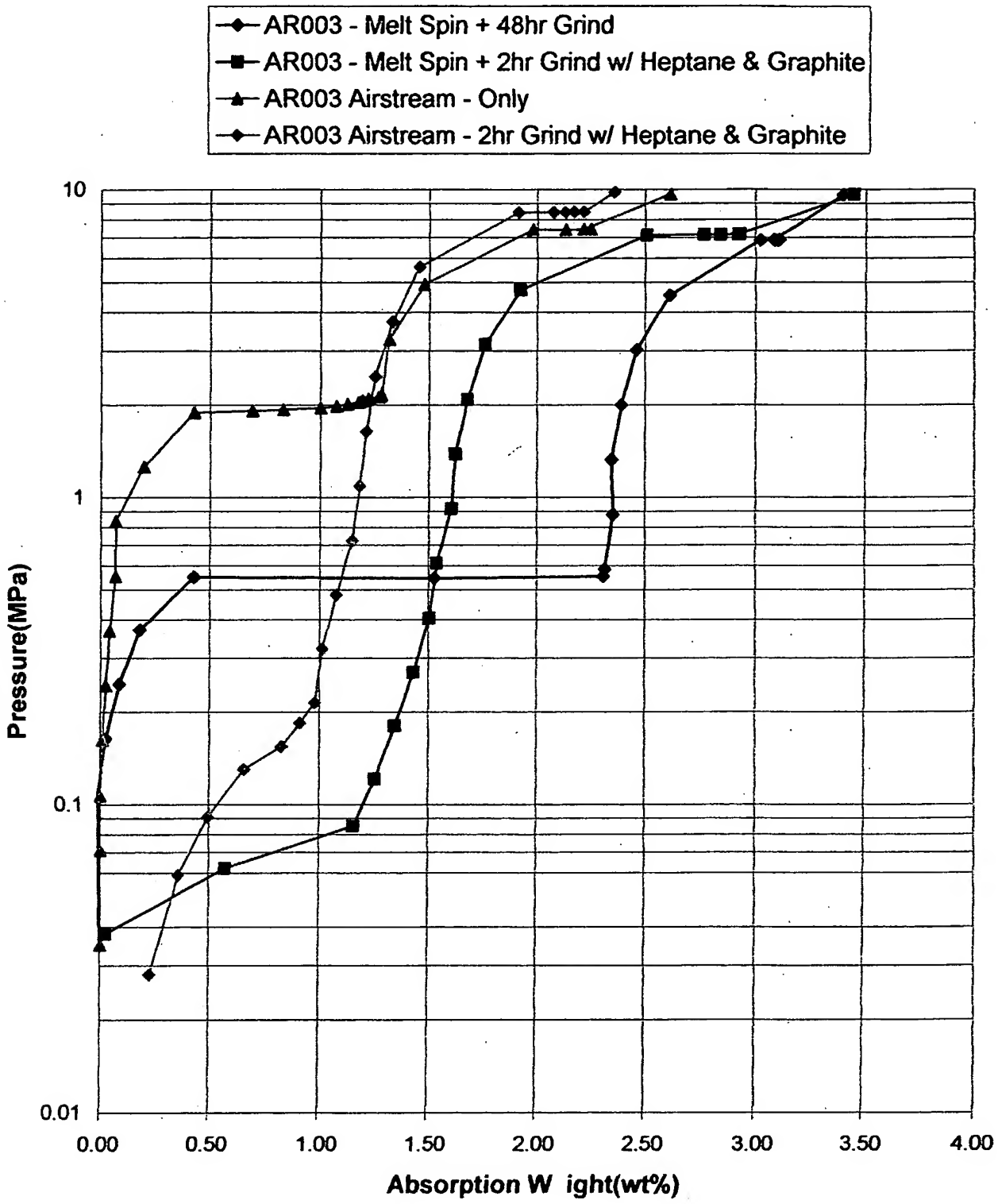

Hydrogen Storage of AR003 at 90°C
AR003 - Melt Spin + 48hr Grind
AR003 - Melt Spin + 2hr Grind w/ Heptane & Graphite
AR003 Airstream - Only
AR003 Airstream - 2hr Grind w/ Heptane & Graphite
10
1
0.1
0.01
Pressure(MPa)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Absorption W ight(wt%)

Figure 20

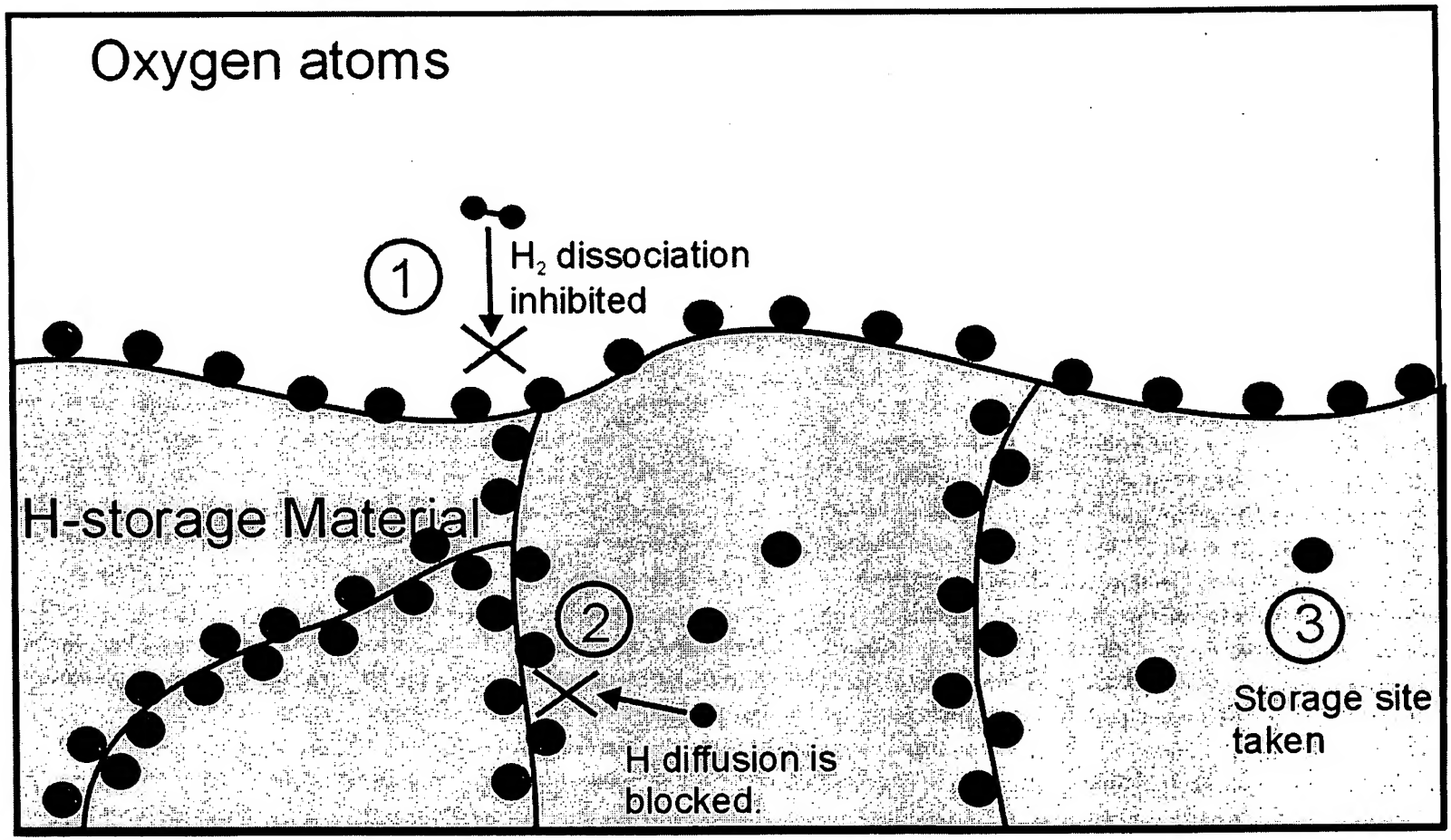

Oxygen atoms
1
H_2 dissociation inhibited
H-storage Material
2
H diffusion is blocked
3
Storage site taken

Figure 21

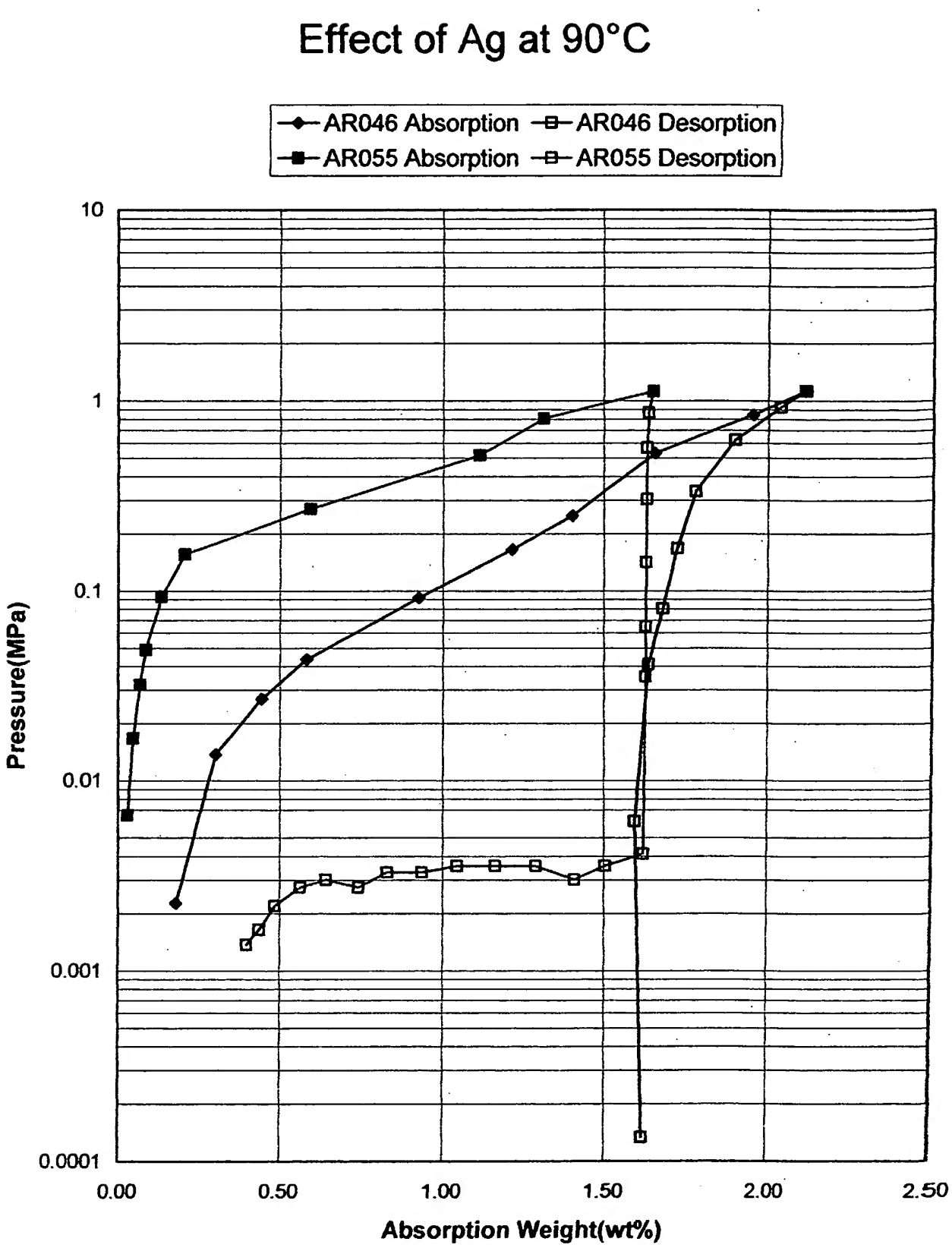

Effect of Ag at 90°C
AR046 Absorption
AR046 Desorption
AR055 Absorption
AR055 Desorption
10
1
0.1
0.01
0.001
0.0001
Pressure(MPa)
0.00
0.50
1.00
1.50
2.00
2.50
Absorption Weight(wt%)

Figure 22

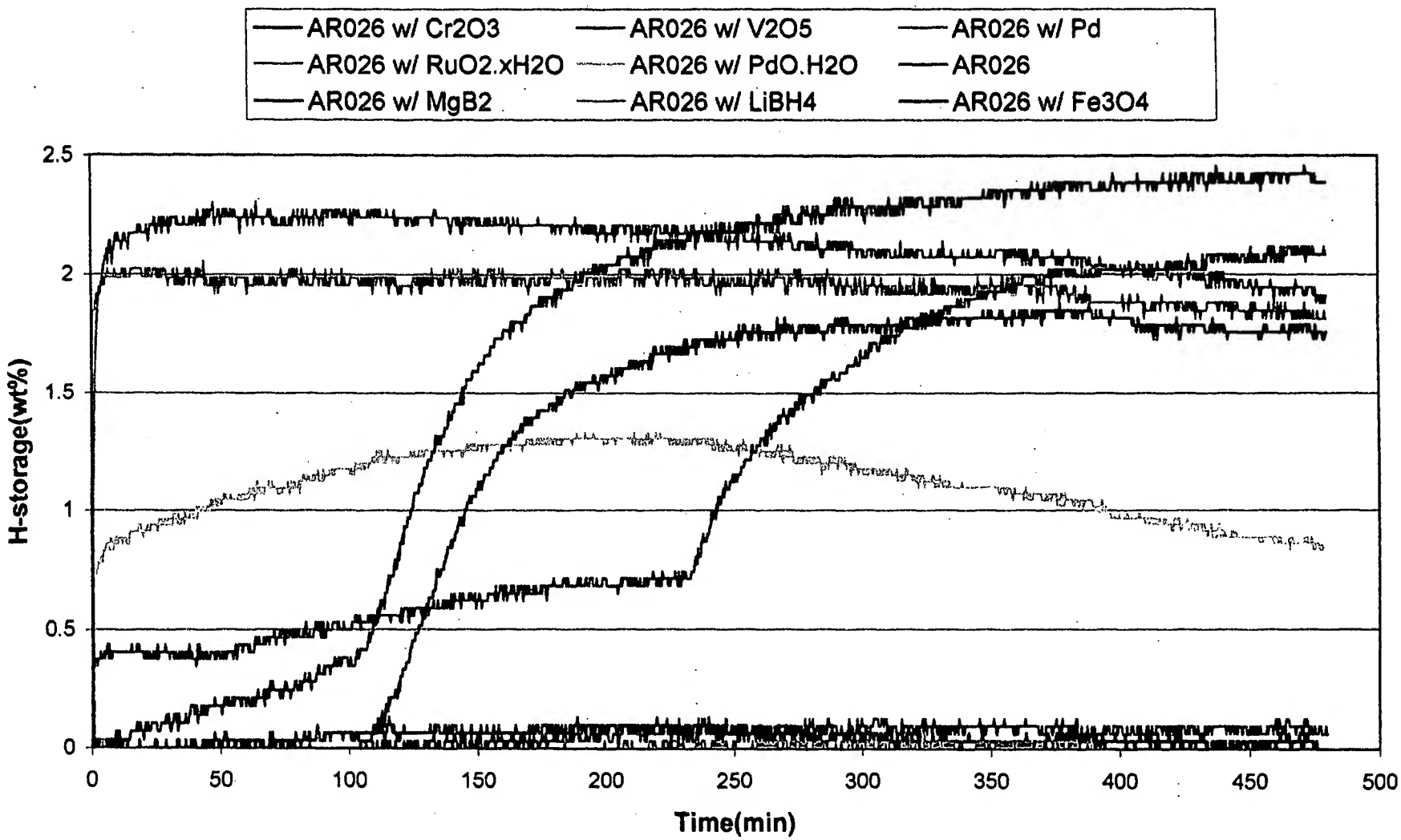

Various Catalysts for Hydrogen Absorption at 90°C
AR026 w/ Cr2O3
AR026 w/ V2O5
AR026 w/ Pd
AR026 w/ RuO2.xH2O
AR026 w/ PdO.H2O
AR026
AR026 w/ MgB2
AR026 w/ LiBH4
AR026 w/ Fe3O4
H-storage(wt%)
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
Time(min)

Figure 23